SHORT REPORT

What is "powder free"? Characterisation of powder aerosol produced during simulated use of powdered and powder free latex gloves

M L Phillips, C C Meagher, D L Johnson

Abstract

***Objectives*—To characterise the distribution of particle size and mass of glove powder aerosol released from powdered and powder free non-sterile latex gloves under controlled conditions.**

***Methods*—Gravimetric sampling and aerodynamic particle size analysis were performed during simulated use of gloves on a prosthetic hand in a chamber designed to minimise background particle concentrations.**

***Results*—Aerosol was detectable for both powdered and powder free gloves under both aggressive and non-aggressive handling conditions. Most of the particles detected had aerodynamic diameter less than 10 μm.**

***Conclusion*—Powder free gloves were not entirely free of powder aerosol. Particles from both powdered and powder free gloves are sufficiently fine to penetrate into the thoracic region of the respiratory tract.**

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Department of Occupational and Environmental Health, University of Oklahoma, Health Sciences Center, PO Box 26901, Oklahoma City, Oklahoma 73190, USA
M L Phillips
C C Meagher
D L Johnson

Correspondence to:
Dr M L Phillips
margaret-phillips@ouhsc.edu

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Adverse reactions to natural rubber latex gloves have emerged as an important occupational health concern for workers who are required to wear gloves as a barrier against infectious agents.[1] The most severe reaction associated with latex gloves, type I immediate hypersensitivity, a rare but potentially life threatening allergic reaction to latex proteins, may be elicited not only by dermal contact with gloves but also by exposure to latex proteins contained in airborne glove powder.[1 2] Powder can become airborne during unpackaging, putting on, and taking off gloves.[1]

Tarlo *et al*[3] showed that airborne latex allergen was produced when powdered latex gloves were used in a hospital laboratory, and that use of powder free latex gloves reduced airborne concentrations of latex allergen in hospital laboratories. Newsom and Shaw[4] found that the mean counts of starch particles detected in air samples in a hospital emergency department showed a significant decrease of 36% after the department changed from powdered gloves to power free gloves. It was suggested that the starch particles detected in this area after the change to powder free gloves resulted from powder carried in on the hands and clothing of personnel from other departments that still used powdered gloves.[4]

Cornstarch powder has long been used on latex gloves as a lubricant to facilitate putting gloves on. Cornstarch or other powder is also used by some (but not all) manufacturers to ease removal of gloves from moulds. For powder free gloves, the powder is removed afterwards by washing. The United States Food and Drug Administration (FDA) has recommended that powder free gloves contain no more than 2 mg residual powder and powdered gloves no more than 120 mg powder.[5] The FDA guidelines formally apply only to gloves for medical use.

The distribution of the size of particles containing latex is relevant to the study of latex allergy because particle size determines the inhalability of aerosol particles and the site of particle deposition in the airways.[6] This study provides a characterisation of aerosol particle size and mass released from one brand of powdered and powder free laboratory gloves under controlled conditions.

Materials and methods

GLOVE BOX DESIGN

A ventilated glove box with a volume of 161 l was fabricated from fibreboard and sealed with a water based paint. The box was equipped with tube fittings for connecting a sampling pump, an exhaust pump, and a particle size analyser which were located outside the box. A high efficiency particulate air (HEPA) filter was attached to an air inlet port to prevent entry of particles from the room when air was being exhausted from the box. The front of the glove box was equipped with a glass panel for viewing the interior and two shoulder length neoprene gauntlets mounted on circular ports. One side of the box was a removable panel and gasket, which was sealed with vacuum grease and bolted down when the box was in use.

PROSTHETIC HAND

A model hand was cast from plaster of Paris with a heavy duty glove as a mould. Because the fingers of the prosthesis were inflexible and

caused perforation of several gloves during trial runs, the fingers were sawn off and the remaining cast was filed smooth. The prosthesis was then painted with enamel spray paint and sealed with a clear gloss. The prosthesis was bolted to a stainless steel plate and placed near the centre of the glove box.

SAMPLING PROCEDURE

Airborne particulate samples were collected for gravimetric analysis on pre-weighed 47 mm glass fibre filters (Whatman International, Maidstone, UK) held in an open face stainless steel cassette which was attached by flexible tubing, through the tube fittings, to a rotary vane sampling pump. The pump flow rate was calibrated at 45 l/minute. The face of the filter cassette was oriented vertically and directed toward the prosthesis at a lateral distance of about 7 cm and a height of about 20 cm above the chamber floor.

At the beginning of each experimental run, all materials were placed in the glove box, which was then sealed. The chamber was exhausted for five air changes with a rotary vane pump at 50 l/minute. An API aerosizer aerodynamic particle size analyzer (Amherst Process Instruments, Amherst, Massachusetts, USA) was used to verify that the background concentration of particles within the chamber was negligible. The exhaust pump was then turned off and the sample pump was started. Gravimetric samples were collected during the successive unpackaging, putting on, and taking off 10 gloves on the prosthetic hand, under conditions of aggressive and non-aggressive handling. Simultaneous particle size measurements were taken with the aerosizer. During aggressive handling a package of gloves was torn open, then one glove was removed from the package and stretched and snapped before placing it over the prosthesis. Aggressive removal was done by pulling the glove fingers and stretching the glove until it snapped off from the prosthesis. During non-aggressive handling the glove was removed from the package and cautiously placed on the prosthesis with no stretching or snapping. Non-aggressive removal was performed by gently rolling the glove from the wrist and slowly removing it from the prosthesis without stretching it. A single lot each of non-sterile powdered latex gloves and powder free latex gloves for laboratory use (Fisherbrand) was used.

In experiments where aerosol release was monitored only during unpackaging and putting on, the sampling pump was run for five air changes after putting on the glove and then turned off; then the filter cassette was covered, the glove was removed, the prosthesis was wiped clean with a dry cloth, and the chamber was exhausted with the second pump for five air changes and checked with the aerosizer. This procedure was repeated for all 10 gloves.

Each experiment was replicated three times.

The filters for gravimetric sampling were equilibrated at 53% relative humidity in a sealed jar before weighing on an electronic analytical microbalance (model A-200DS, Denver Instrument, Arvada, Colorado, USA) with ±0.01 mg sensitivity.

POWDER CONTENT ON GLOVES

The ASTM D6124 method[7] was used to measure the powder content on powdered and powder free gloves from the lots used in the aerosol experiments. An average of 0.2 mg residual powder was found per powder free glove and 126 mg powder per powdered glove.

Results

The results of gravimetric sampling are presented in table 1. Aerosol was detected for both powdered and powder free gloves under both aggressive and non-aggressive handling conditions. The amount of aerosol generated from powdered gloves was about 32 times greater than from powder free gloves during aggressive handling; a sevenfold difference was found during non-aggressive handling. Aggressive handling of powdered gloves produced about 26 times more aerosol mass than non-aggressive handling. According to a two factor analysis of variance (ANOVA), all these differences were significant. The difference in the amount of aerosol collected during experiments with and without taking the gloves off was found not to be significant by the Welch test, indicating that under aggressive handling, the powder was released primarily during unpackaging and putting gloves on.

Aerosizer data indicated that the count mean aerodynamic equivalent diameter of particles from powdered gloves was 11.4 μm under aggressive handling and 11.1 μm under non-aggressive handling. The count mean aerodynamic equivalent diameter of particles from powder free gloves under both aggressive and non-aggressive handling was 7.4 μm. The distributions of particle size were bimodal, with modes at about 1.3–2 μm and 8–11 μm aerodynamic diameter for powdered gloves and 1.3–1.6 μm and 4–6 μm for powder free gloves. Particles of less than 10 μm aerodynamic diameter contributed to 14%–39% of mass from the powdered gloves and 70%–84% of mass from the powder free gloves.

Table 1 Gravimetric analysis of glove powder aerosol samples

	Handling conditions	
Glove type	*Aggressive*	*Non-aggressive*
Mass produced by 10 gloves during unpackaging, putting on, and taking off (mg):		
Powdered	7.59	0.51
	8.56	0.13
	10.1	0.52
Geometric mean	8.69	0.33
Powder free	0.3	0.06
	0.37	0.06
	0.18	0.03
Geometric mean	0.27	0.05
Mass produced by10 gloves during unpackaging and putting on (mg):		
Powdered	6.01	
	4.48	
	9.34	
Geometric mean	6.31	
Powder free	0.30	
	0.15	
	0.33	
Geometric mean	0.25	

Discussion

Experiments under controlled conditions showed that for the brand of latex gloves used in this study, 10%–20% of the residual powder on powder free gloves became aerosolised during aggressive handling. This result suggests that the detection by Newsom and Shaw[4] of airborne starch particles in areas where powder free gloves were used might have been due in part to aerosolisation of residual powder from powder free gloves, rather than solely to infiltration of powder from areas in which powdered gloves were used.

The latex allergen content of the glove powder collected in these experiments was not measured. Other studies have indicated that airborne latex allergen concentrations are much lower in workplaces in which powder free gloves were used than in those with powdered gloves.[3 8] It should be noted, however, that latex allergen content differs not only between powdered and powder free gloves, but also among different brands of powder free gloves.[9]

The distributions of particle size indicate that powder aerosol from both powdered and powder free gloves can penetrate into the thoracic region of the respiratory tract. This result raises concern not only because of the potential entry of latex allergen into the lung, but also because it has been suggested that glove powder may serve as a carrier for multiple antibiotic resistant bacteria.[4]

This pilot study of aerosolised glove powder was limited to one lot each of powdered and powder free non-sterile laboratory gloves from one manufacturer. The gloves were manufactured in Thailand for a leading United States scientific supply firm, which was unable to provide information about the manufacturing process. Additional studies are recommended to determine the amounts of powder and allergen released during use of powder free gloves from many manufacturers and different lots.

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